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THE STATE OF GROUP SUPPORT SYSTEM RESEARCH THROUGH A SURVEY OF PAPERS 1980 to 1991

by

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Group Support Systems (GSS) have experienced tremendous growth during the 1980's. Group Decision Support Systems (GDSS), Negotiation Support Systems (NSS) and Computer Supported Collaborative Work (CSCW) systems are examples of the acronyms that represent the application of computer technology to group work. As the GSS field is in a period of rapid growth, it is difficult to keep abreast of the existing literature, current research, issues and future trends. This thesis provides a short tutorial on GSS, reviews existing GSS taxonomies, identifies key research findings, issues, and future trends, and proposes a classification framework to aid in information retrieval from the extensive GSS literature database provided.

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The State of Group Support System Research Through a Survey of Papers 1980 to 1991

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ABSTRACT

Group Support Systems (GSS) have experienced tremendous growth during the 1980's. Group Decision Support Systems (GDSS), Negotiation Support Systems (NSS) and Computer Supported Collaborative Work (CSCW) systems are examples of the acronyms that represent the application of computer technology to group work. As the GSS field is in a period of rapid growth, it is difficult to keep abreast of the existing literature, current research, issues and future trends. This thesis provides a short tutorial on GSS, reviews existing GSS taxonomies, identifies key research findings, issues, and future trends, and proposes a classification framework to aid in information retrieval from the extensive GSS literature database provided.

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I. INTRODUCTION

Although Group Support Systems research (GSS) is in the early stages of its development, many focuses for this development have appeared. Several distinct disciplines have been developed by applying Information Technology on computer support to groups processes. Of these processes, the Group Decision Support Systems (GDSS) tend to focus broadly on computer support for tasks related to decision making, the Computer Supported Cooperative Work (CSCW) applies computer technology to facilitate group communications, and Negotiation Support Systems (NSS) deal primarily with consensus decision making in a non-cooperative environment. Although variances exist in the tools and processes for each of these methodologies, a review of their supporting literature may be compiled by grouping them as a core concept of GSS. Individual specialties are addressed separately when discussing the finer points of the proposed literature classification framework in Chapter V.

A major concern in the environment of an emerging technology is that the lack of communication or coordination between researchers may lead to a repetition of previous errors, a wasting of effort, or oversight of critical areas.

GSS has slowly moved from the arena of experimental study performed in universities and government to being slowly

implemented on a commercial basis. Reasons for the delays are due to the large start-up costs, coupled with the uncertainty of results obtained from existing studies. The question also exists as to whether the system is commercially viable or a risk-laden venture. This issue may be classified by studying GSS research literature to date and providing a categorized reference of applicable literature to support a coordinated level of research and to provide clear-cut benefits to "bottom line" managers. Failing this, GSS may very well become the "solution without a problem". The current research potential of GSS would make this a disappointing conclusion. Reinforcement of the positive findings to date can be obtained by thorough scientific analysis of coordinated research.

A Tutorial of GSS is presented in Chapter II, and begins by providing a current perspective of GSS designs, and a review of the problems presented in group meetings that prompted the generation of the tools and features of GSS. A review of the commonly referenced GSS tools/system vendors, the benefits, and barriers to GSS implementation is also presented. The Tutorial is written to provide a background for the remaining chapters of the thesis.

Chapter III provides examples of current and proposed taxonomies presented in current literature as an overview of the GSS field. Issues in GSS research are reviewed in Chapter IV as determined by a cross-sectional analysis of 43 papers on GSS.

The focal point of this thesis is to go one step further than a tutorial to suggest a proposed literature classification framework for GSS references. Chapter V provides a distillation of the taxonomies that will lend itself most readily to this endeavor. The logic for this framework will be described, but it is fully realized that differing opinions will emerge. The purpose is not to present another taxonomy for the industry to adopt, but rather to provide an easily understood classification for the GSS literature review. The simple act of providing an overview of research to date has yielded several general trends that are discussed in Chapter IV.

The thesis concludes with a discussion of ideas generated by this compilation of papers, and proposes several questions for further study. Table 4 provides the tabular output of data from this paper's analysis of GSS research issues in Chapter IV. A separate reference section provides the listing of articles used in generating the text of this paper, and Appendix A offers an extensive listing of the GSS literature since 1980 providing the bulk of the material for the thesis database.

II. TUTORIAL

A. OVERVIEW

The definition of GSS as used in this paper provides the best starting point for a tutorial. The below-listed definition introduced by Dennis, et al., (1988) is described as Electronic Meeting System (EMS), however, it provides a workable definition for the Group Support Systems (GSS) discipline. This definition is:

> An information based technology that supports group meetings, which may be distributed geographically and temporally. The IT environment includes (but not limited to), distributed facilities, computer hardware and software, audio and video technology, procedures, methodology, facilitation, and applicable group data. Group tasks include, but are not limited to communication, planning, idea generation, problem solving, issue discussion, negotiation, conflict resolution, system analysis and design, and collaborative group activities such as document and sharing. (Dennis, et al., 1988)

This definition is selected primarily for its all-encompassing span of group-related computer systems. Since there are so many aspects of GSS that are common to each of the GSS subdisciplines of GDSS, NSS, and CSCW, the thrust of this tutorial will be to cover the overall background of GSS with brief explanations about the subdiscipline variances. This overview is based on current knowledge, representing what is expected to be the beginning of this field. The other chapters of this paper will delve into the specific issues, organization, and design of GSS. While GSS (and, more

specifically, GDSS) may have evolved from the realm of Decision Support System (DSS) technology, they are more than just an extended DSS for groups. While the model base and database aspects of DSS are an integral part of a computer-supported GSS, it is more than the concept of applying audio, video, information system, and telecommunication technology to structuring the group decision process that forms the basis of this discipline. These tools and procedures are used primarily in group support systems for the choice or solution aspects of structured or unstructured problems. In addition to a discussion of the various GSS environments, tasks, and organizationware (GSS procedures, people and protocols (Kraemer and King, 1988)), the tutorial briefly summarizes the key issues and the status of GSS implementation to date. This overview approach should help the reader appreciate the variances in the methodologies proposed to date, as noted in Chapter III, and the logic used in settling on the literature classification framework proposed in this paper.

B. COMMON GSS ENVIRONMENTS

The systems discussed in this section do not represent an exhaustive listing of existing systems, but rather are intended to familiarize the reader with some of the commonly referenced facilities and their associated physical designs (environments). In most cases, these are not yet commercial products, or involve products no longer in use. They do,

however, exemplify the common GSS referenced in the literature, and provide an insight into the most representative variations of GSS design.

The four descriptions of GSS environments listed below include: the Decision Room (DR); the Local Area Decision Net (LADN); the Legislative Session; and the Teleconference.

1. Decision Room

The most common form of GSS found is one that reflects smaller groups meeting face-to-face, the Decision Room. The Decision Room is generally a mid-sized conference room (somewhat like a boardroom). It may have a horseshoe or semi-circular shaped table or seating arrangement to allow visual contact among members. Generally, a large screen video projection system with video terminals/monitors and computers or terminals for individual inputs and access to information sources is arrayed around the projector(s). The software and organizationware (Kraemer and King, 1988) to support Decision Rooms generally provides decision analysis and modeling, multi-user interface, vote tallying and display, democratic decision-making and meeting protocols. Decision Rooms with specific subdiscipline focuses (such as non-cooperative decision making) may additionally support conflict resolution, idea generation and organization, agenda setting, or post-session analysis tools.

Some examples of Decision Rooms are as follows: University of Arizona PLEXSYS Electronic Meeting Systems

(ENS); Automated Decision Conferencing, Decision Technologies, Group State University of New York (SUNY); Capture Lab, Center for Machine Intelligence, University of Michigan; COLAB, Xerox, Palo Alto Research Center (PARC); NEGO/GDSI, Carleton University; Project Nick, Microelectronics and Computer Technology Group (MCC), Option Technologies Inc.; The PDD, International Computers Limited; Software Assisted Meeting Management (SAMM), University of Minnesota.

2. Local Area Decision Net

Continuing with the theme of small groups, but shifting to the multiple site scenario, we enter into discussion on **Local Area Decision Nets.** These dispersed sites may be individuals at their office work stations, or perhaps a number of workstations linked with a facilitator in a Decision Room facility. It is in this scenario that the idea of asynchronous meetings comes up most often since the LADN is well-suited for the temporarily displaced process of document generation or sharing. Another attraction of LADN is its lower costs. Except in cases where a portion of the group may use a facilitator/chairman and a computer-supported conference facility, the hardware requirements of this environment are usually quite small. Most systems and software support for LADNs are written to be used on simple personal computers or workstations. The exception may be where audio and/or video links are added to the network requirements of the data channel link. While some of the LADN systems noted below are

primarily expansions of E-mail and calendaring tools, this GSS environment is intended to primarily focus on those systems maintaining the dynamics of group or face-to-face communications. The linking of individual workstations with a decision room may call for the addition of audio and split-screen or window flexibility, but it is more likely that the more economically austere computer-to-computer link would be desired. The software to support LADNs usually encompasses terminal linkage or real-time meeting scheduling or calendaring, network support software, shared-bit map or split-screen interactive communication, and shared applications to ease the data exchange. Unfortunately:

> ...some studies indicate that in LADN's, most participants report that computer teleconferencing hardly feels like a meeting at all, and many are unwilling to participate in them more than a few times. (Kraemer and King, 1988)

Some of the GSS supporting the LADN concept are: CONVERSE, Carnegie-Mellon University; Coordinator, Action Technologies; For Comment, Brodebund Software; Higgins, Conetic Systems Inc.; LIFE, Motorola Computer Systems; Office Works, Data Access Corp.; Syzygy, Information Research Corp.; WordPerfect Office, WordPerfect Corp.; and MPCAL, CDS, RICAL, Massachusetts Institute of Technology. (Nunamaker and Vogel, 1989; Kraemer and King, 1988)

3. <u>Teleconference Facility</u>

The next scenario described is the geographically-dispersed large group environment, the Teleconference

Facility. The primary concern here is to emulate face-to-face meetings for geographically-dispersed groups. As this scenario encompasses audio, video, and data link channels between two or more meeting rooms, the resulting number of participants generally puts this scenario into the category of a "large" group. While computer support may be available to the participants, the primary thrust is to provide video and audio teleconferencing support with supplemental hardware such as facsimile machines and printers. The software used to support the teleconference environment primarily focuses on the communication of audio, video, and data channels. Some of the pre-session, agenda and protocol organizationware of the decision room environment may be implemented, and a facilitator or chairman is likely to be located in one of the rooms. (Kraemer and King, 1988)

Several systems have been designed to support Teleconferencing and with additional services (such as that provided by AT&T's Picturephone Service) as follows: Commune, Xerox Palo Alto Research Center (PARC); Media Spaces, PARC; and Multimedia Conferencing Project, Information Sciences Institute. (Nunamaker and Vogel, 1989)

4. Legislative Session

The Legislative Session GSS is designed to support a large group meeting at the same location. In this environment, each person will still have access to an input device and monitor, but may be sharing access with other

members due to the groups size and resource limitations. Additionally, access to the public screen or the monitors of the members may be restricted or controlled in a hierarchical or automated fashion by a facilitator or chairman. The larger group size may require shifting to a tiered seating arrangement, such as the University of Arizona facility. At the Arizona Legislative Session facility, two large screen projectors are provided to give additional support and visual feedback to the individual monitors and standard conference audio-visual equipment. Communication software and meeting protocol organizationware is a more critical issue in maintaining group dynamics due to a reduction in face-to-face contact. Chapter V (GSS Research Issues) addresses additional issues for large group dynamics. The Arizona Electronic Meeting System has developed a variety of consolidation and structuring tools under its PLEXSYS design including Session Management, Idea Generation, and Idea Organization to maintain the advantages of large group input without overloading the system with an increased communications burden.

The Arizona EMS, the most widely referenced Legislative Session environment, was reported in 1989 to have been duplicated at six sites within IBM. (Nunamaker and Vogel, 1989).

While the three-dimensional taxonomy described below breaks the range of environments down to only the four major environment types discussed above, the actual variances

between GSS environments are almost as numerous as the number of sites themselves. This wide variance in GSS design, discussed in Chapter V, is one factor contributing to the difficulties in building robust conclusions about GSS experimental results.

C. GSS TOOLS/FEATURES

A discussion of GSS software tools is best approached by first looking at the expected GSS needs. The necessary features may then be determined. A brief summary is also given listing existing tools. It is difficult to be more specific about tool design without an in-depth search of specific technical literature written by the various system developers.

1. Problems/Features

Table 1 is a compilation of GDSS (GSS) problems or needs as listed by DeSanctis and Gallupe (1987), aligned with the corresponding proposed tools/features. In their discussion, DeSanctis and Gallupe (1987) propose three technological support levels for GDSS. Level 1 features target the removal of common communication barriers. Level 2 features provide additional tools to reduce the uncertainty in the group decision process using decision modeling and group decision techniques. Level 3 proposes features that control the pattern, timing, or content of the discussion. DeSanctis and Gallupe (1987) point out that the higher the level, the

TABLE 1

GSS GROUP PROBLEM/NEEDS VERSUS PROPOSED FEATURES

GROUP PROBLEM OR NEED	GSS FEATURE
LEVEL 1	
Sending and receiving information afficiently among all parties or specific group members	Electronic massaging, broadcast or point-to-point
Access to personal data filas or corporate data during the course of a meeting	Computer terminal for each group membar, gataway to a local araa network or central computer
Display of ideas, votes , data, graphs, o tables to all members simultaneously	Larga common viewing screen or "publio" screen at each group member's terminal
Raluctanca of some members to speak their due to their shyness, low status, or controversial ideas	Anonymous input of idaas and votas
Failure of some members to laziness or "tuning out"	Activa solicitation of ideas or votas from each group membar
Failure to efficiently organize and analyza idaas and votes	Summary and display of ideas; statistical summary and display of votas
Failure to quantify preferences	Provide rating scalas and/or ranking schamas' solicit and display ratings and rankings
Failure of davelop a meating strategy or plan	Provida a mock aganda whioh the group can complate
Failure to stick with the meeting plan	Continuously display the agenda; provide a time clock; automatically display agenda items at the appropriata tima
LEVEL 2	
Need for problem structuring, planning, and scheduling	Planning modals, a.g., PERT,CPM, Gantt
Decision-analytic aids for uncertain future events	Utility and provability assessmant modals, e.g., decision trees, risk assessment
Decision-analytic aids for resource allocation problems	Budgat allocation models
Decision-analytic aids for data-oriented tasks	Statistical methods, multi-critaria dacision models
Decision-analytic aids of preference tasks	Social judgment models
Desire to use a structured decision technique but insufficient knowledge or time to use the technique	Automate tha Delphi,Nominal, or othar idaa-gathering and compilation technique(s); provida an on lina tutorial for the group or a human facilitator
LEVEL 3	
Desire to enforce formalized dacision procedures	Automatad Parliamentary Procadure or Robart's Rulas of Ordar
Desire to select and arrange an array of rules for discussion	Rule base; facility for rule selection and application
Uncartainty about options for meeting procaduras	Automatad counselor, giving advice on available rules and appropriate use
Desire to develop rules for the meeting	Rule-writing facility

more dramatic the intervention into the group decision process. The table gives a good overview of all three levels of tool support and provides the reader with a consolidated view of perceived GSS needs.

2. GSS Providers/Systems

The GSS field of research does not have a single, integrated GSS that incorporates the features of all three levels as proposed by DeSanctis and Gallupe (1987). Nor does any available GSS support the requirements of the three general GSS task purposes of **choice, generate, and negotiate** (discussed in Chapter V). Given the software proprietary battles, the immense complexity of an all-encompassing system, and the inherent maintenance nightmares of incorporating subsequent tool changes into such a system, it is unlikely that such a fully-integrated, all-encompassing system will be developed or be able to survive. Unfortunately, GSS software or organizationware tools present today are generally incompatible from system to system, and for the most part, are not even commercially available. This drawback reflects the issue of difficulty in obtaining consistent results among researchers (see Chapter V). Table 2 provides a list of the GSS software systems and/or tools most frequently referenced in GSS literature. (Kraemer and King (1988); Nunamaker and Vogel (1989); and Bui (1987).) The systems referenced here address the all-encompassing approach desired in the GSS group process. Some of the additional systems referenced in the

TABLE 2

GSS PROVIDERS/SYSTEMS VERSUS FEATURES

PROVIDER	SYSTEM	FUNCTIONS
Applied Futures, Inc.	CONSENSOR	Vote tabulation and display
Carleton University, School of Business	NEGO and/or GDS1	Negotiation support, iterative stakeholder analysis and proposal generation [nNunmaker and Vogel, 1989]
Compshare	SYSTEM W, EXPRESS	Data management, modeling statistical analysis, graphics, report generation, PC communications
Decisions and Designs, Inc.	Decision conference	Interactive decision analysis (six models), conference facility, decision analysis, consultation
MIT Laboratory for Computer Science	MPCAL, CDS, RTCAL, MBlink	Support of geographically separated local group work, including calendar management, real-time conferencing, and collaborative document editing
Naval Post-graduate School	CooP	Prioritizing and aggregation of preferences, multi-criteria decision making, consensus seeking algorithms, resource sharing,alternative identifying and evaluation [b27a]
OPTION TECHNOLOGIES	Decision Room	Idea recording and voting [Nunmaker and Vogel, 1989]
Perceptronics, Inc.	GROUP DECISION AID	Interactive decision tree; analysis, tutor, documentation
SRI International	QUIKTREE, APLTYER	Interactive decision tree analysis for individuals
SUNY, Albany Decision Techtronics Group	NA	Interactive decision analysis (six models), data management, graphics, decision and process consulting
UCLA Cognitive Systems Laboratory	NA	Group decision theory and analysis
University of Arizona Planning Laboratory	PLEXSYS	Electronic Brainstorming (EBS), knowledge accumulation/exploration, Organization analysis, stakeholder identification and analysis, issue analyzer, session (agenda/report) direction, voting (ranking/prioritizing), alternative evaluator (MCDM), resource allocation, LAN support
University of Minnesota, IS Department	SAMM	Nominal group technique, stakeholder analysis, spreadsheet and allocate analysis tools, data management tools, problem issue defining, recording, display of solution criteria/alternative evaluation /voting [Nunmaker and Vogel, 1989]
Xerox PARC	COLAB	Computer support of face-to-face group work, EBS (COGNOTER), electronic white board,idea organizer distributed meeting [Nunmaker and Vogel, 1989]

discussion of Local Area Decision Nets (LADN) and some CSCWs are omitted here, as they generally support only the most rudimentary aspects of GSS (E-mail, data capture/sharing, application sharing, etc.).

D. BENEFITS AND BARRIERS

Attempts to analyze the benefits of GSS use and the barriers to its future growth quickly become complicated. Most of the experiments have widely varying independent variables, making it difficult to analyze the results. Additionally, the theories about the group decision making process are largely unproven, making it even more difficult to determine the effect of that process on a GSS. (Chapter V is devoted to addressing and summarizing the predominant GSS issues.) The stated benefits of GSS as a result are often laden with qualifiers explaining the context in which those benefits were realized. Barriers to the growth of GSS are also tied closely to the research issues that are discussed in Chapter V. However, some broad statements can be made concerning the benefits and barriers to GSS without listing numerous caveats.

1. Benefits

GSS are a hopeful remedy for:

> ...the clash of two important forces, the environmentally-imposed demand for more information sharing in organizations, and the resistance to still more meetings. (Huber, 1984)

The benefits of GDSS use are broken into three classes by Kraemer and King (1988). The three classes are affective benefits, facilitation of protocols, and the improvement in quality of information available for decisions. Their discussion is referenced here since these benefits are also relevant to the broader definition of GSS. The affective benefits stem from the perception that GDSS tend to enliven meetings and potentially encourage group cohesion. An advantage of this benefit is that the technology directly affects the group dynamics. This intervention into the process appears to allow the group to focus more quickly on the issues, to reach decisions more quickly and to produce greater satisfaction within the group process. A subtle, but important factor to consider is whether the decisions made with the GSS are of higher quality than those made manually.

The facilitation of protocols refers to the improvement in the group decision making techniques that fosters more participative decision making, a better determination of key issues, and achieving group consensus on required actions. Generally, it is through GSS technology that these protocols are enhanced. Graphic display, automated voting, and information retrieval and modeling serve to facilitate the rational decision making process. Unfortunately, one of the biggest variables in the use of GSS technology is how to acknowledge the fact that a great deal of decision making may not even be made under the rational model. (Kraemer and King, 1988)

Generally, another significant benefit of GSS is the improvement in the quality of information available for decisions. Kraemer and King are careful to make the distinction that it is the quality, not quantity of information that is relevant to the decision worth. As yet, a great deal of the information provided at meetings is tailored ahead of time versus the on-line database access that one commonly envisions with an individual DSS. The availability of that information (potentially from several different members) assists in qualifying the validity of assumptions and facts considered in the decision process.

Dennis, et al., (1988) draws several other general benefits from the analysis of GSS (PLEXSYS) technology in group support research. The first of these is the implication that organization productivity will increase. Next, GSS technology should allow and even encourage greater participation of the members of the group without a corresponding drop in productivity. The accompanying increased domain of knowledge and skills, political acceptance of widely-decided policies, and greater dissemination of the decision factors experienced by an increasing group size would make larger meetings desirable if productivity was not adversely impacted. Incorporation of GSS may open this door. Another aspect of a beneficial increase in group size/participation is the capability that a GSS provides in integrating members among the full range of organizational hierarchy. This increased

decision participation promotes inter-level communication and speeds the collective organizational approval of decisions. (Dennis, et al., 1988)

2. Barriers

Kraemer and King (1988) distill the multitude of barriers in obtaining a successful GDSS down to the categories of technical problems, problems, with the GDSS package (technology, organizationware, people), and problems due to an incomplete understanding of the decision making process.

Technical problems reflect the shortcomings in the availability or capabilities of the hardware and software technology to support a GSS. Accessibility and flexibility in using computer resources (location and interconnecting terminals, PCs, processors, printers, and their cost-effective use), video display technology limitations (resolution/cost), graphic display capacity (speed and flexibility), and modeling and analysis software (more powerful yet still user friendly) are all technical features that are either not yet available or are prohibitively expensive. The economies of scale have not yet been realized by the vendors/providers given the narrow market of GSS users. (Kraemer and King, 1988)

Another problem lies in the GDSS integrated package of technology, organizationware, and people. The failure of most GDSs to survive in the commercial environment speaks of their inability to provide a technologically sound, organizationally stable, financially sound, and demonstratively productive

system. The operation and results of GSS in the public sector or in the university environment do not appear to be directly translatable to the commercial environment.

The pervasive problem of providing complete knowledge into the decision making process is one of the most glaring barriers to successful implementation of GSS. The rational model of decision making is the one most technically feasible to simulate with GSS tools. In actuality, however, the rational model represents only a portion of decisions made. The remainder of the decisions are handicapped by tools that cannot accurately evaluate the "fuzzy logic" or hidden agendas actually being employed. (Kraemer and King, 1988)

One of the barriers that Dennis, et al., (1989) expand on is the necessity to integrate experimental research and field study. Inherent differences in organizational context, group characteristics (size/task/information management needs), and in the GDSS environment and group work process allow for inconsistent results and questionable conclusions between the research groups and business groups encountered in field studies. As mentioned earlier, the worth of the product to the customers is greatly influenced by the quality and faith in the reported findings.

One additional consideration that must be evaluated is the organizational resistance encountered in the introduction of a GSS. The resistance may become a barrier to its survival. Generally, however, organizational commitment,

management sponsorship, and capital investment in facilities are well understood problems that may be resolved. While there are some significant barriers to increased implementation of GSS, an abundance of positive results and potential benefits exist that may be substantiated by valid and coordinated experimental and field studies. It is interesting to note that the improved data gathering capabilities available in GSS technology may provide the key to better understand the theories of group dynamics, thereby strengthening the argument for its expanded use.

II. <u>SURVEY OF CURRENT GSS TAXONOMIES</u>

A. JUSTIFICATION

A survey of the predominant GSS taxonomies or classification schemes to date is appropriate for two reasons, as follows. Looking at the progression of classification schemes/taxonomies developed over the decade provides an appreciation for the evolution of concerns and issues regarding GSS. This review leads to a background for the logic used in the literature search classification scheme presented in Chapter V. The need for widely-accepted, concise taxonomies to categorize GSS literature and research has become critical as the variety of GSS endeavors and literature grows. Pinsonneault and Kraemer (1990) point out that:

> Despite the recent research efforts, there are few clear indications of how electronic meetings affect groups. Empirical findings often appear contradictory and inconsistent. In an effort to bring order to recent research, this paper systematically reviews and assesses the empirical research.... (Pinsonneault and Kraemer, 1990)

The classification scheme they propose reflects the one used in several of their earlier articles (Kraemer and Pinsonneault, 1989; Pinsonneault and Kraemer, 1989) where they also address two other facets in the argument for well-constructed taxonomies:

> Now that more group technologies become more widespread...field studies in real organization settings are needed. Such field studies will have less control

> over the contextual and independent variables than in laboratory settings. (Kraemer and Pinsonneault, 1989)

> When one analyzes the research without differentiating technological supports, one finds very inconsistent results. (Pinsonneault and Kraemer, 1989)

Both of these statements echo increasingly popular sentiments in the field. Gray, Vogel, and Beauclair (1990) develop the second point even further by introducing a scheme for codifying the "distance" between experiments based on their common independent variables. Multi-dimensional scaling is then applied to look for "clusters" (and therefore, comparable) experiments. They suggest that simply stating the support technology used is insufficient to compare separate experiments to verify robustness of experimental results. These models, and other frequently referenced earlier taxonomies, will be summarized to provide the reader a more thorough understanding of the evolution of GSS literature and the field.

B. EARLY CLASSIFICATION MODELS OF GSS

Early models proposed in the GSS literature generally focused on the perceived design and research issues addressed by various authors. These models aided in differentiating between GSS, but did not fully appreciate the challenge the field was to face in validating result consistency between experiments. Quite likely, 5-10 years ago, the frequency and degree with which the contradictions would occur was not recognized.

Huber (1984) forwarded some of the first constructs with regard to organizing ideas and issues in GDSS when he addressed three "major issues" in their design; system capabilities, system delivery modes, and system design strategies. System capabilities addressed the flexibility, reliability, and sophistication of the system. System delivery modes reflected whether the GDSS was to be portable, or was to be fixed at either the user's or vendor's site, and included the perceived advantages and disadvantages of each option. His "alternative" design strategy, based on anticipated group task or activities, described the GSS "task" activities of: information retrieval (or generation), information sharing, and information use. This task classification could be construed as a forerunner of taxonomies that differentiate GSS by task type (e.g., choice, generate, or negotiate task purposes). Huber also briefly addressed the definition of GSS in terms of hardware, software, language, and procedures in support of people, an analysis of system components that also has weathered the years.

DeSanctis and Gallupe (1985) provide a couple of key concepts used in the support of other classification schemes that have surfaced over the years. Their paper formalizes the notion of GDSS being a system of software, hardware, people, and procedures, and goes into the fundamental aspects of each area in some depth. DeSanctis and Gallupe also provide one of

the most commonly referenced early multi-dimensional models of the GSS environment. This first model had two axes describing the four general environment scenarios of a GDSS. One axis reflected the proximity of GDSS members: either close, as in decision rooms; or dispersed, as in teleconferencing. The other axis described scenarios that varied in duration: limited as in a decision room meeting, or on-going as you might see in a local area decision network between managers in the same building who are "stepping" in and out of deliberations throughout the day.

C. CLASSIFICATION MODELS TO SUPPORT RESEARCH

The taxonomies discussed in this section are noteworthy as they portray well thought-out schemes, but also point out the need for workable taxonomies to give structure to GDSS research and design. DeSanctis and Gallupe (1987) followed up their earlier two-dimensional environment model (DeSanctis and Gallupe, 1985) with an expanded model that dropped the session duration axis, but introduced two new axes, group size and task type. DeSanctis and Gallupe reference social behavior studies and the limited GDSS research to date in defining group proximity and group size as critical factors in GDSS design. The group task axis in the model is more critical as it relates to the selection of the procedures, goals, rules and roles characteristic of the particular task environment, rather than to the physical environment.

The four environmental settings formed by the intersection of member proximity and group size (respectively), are as follows: (face-to-face, smaller) Decision Room; (face-to-face, larger) Legislative Sessions; (dispersed, smaller) Local Area Decision Network; and (dispersed, larger) Computer-Mediated Conferences (and/or Teleconferences as used in this classification framework).

The six task types that DeSanctis and Gallupe forward as the third axis are condensed to three task purposes; generating, choosing, and negotiating. This schema of classifying GDSS (or GSS) by their purpose or task is a concept adopted and employed in the literature classification scheme selected for this thesis. Its relevance to the classification of research is further supported by its acceptance by Kraemer and Pinsonneault (1990).

One last contribution to GSS taxonomies that this paper (DeSanctis et al., 1987) provided was in the concept of Level 1,2, and 3 GDSS. This three level classification of GSS technological support was explained in further detail in the Tutorial of this paper (Chapter II). The concept of varying levels of technological support for GDSS is not new, as others have recognized the need for more sophisticated involved GSS systems. Codifying of the expected group problems and corresponding GDSS features for a given level of sophistication has provided a useful analogy.

Two other papers around this time frame (Kraemer and King 1988, Dennis et al., 1988), lay the groundwork for evolution of more rigorous taxonomies to support research. The paper by Dennis et al., (1988) not only describes a meeting system conceptual model consisting of environment, group process and outcome, and method for "Electronic Meeting Systems," but also proposes the concept and components for a research model. Kraemer and King (1988) discuss a sociotechnical "package" model of hardware, software, organizationware, and people, including six environments characterized by their technology packages, with examples of existing systems.

Dennis et al., (1988) further recognizes the scope of the field of electronically supported group meetings stepped back from the traditional, narrow definition of GDSS and define a term, Electronic Meeting Systems (EMS). The Electronic Meeting System is a broader definition of the Group Decision Support Systems. The EMS recognizes that research should support not only the specific needs of the GSS, but also the decision making task, the idea generation systems, and the interdependent features of cooperative and non-cooperative group systems. The EMS conceptual model differs from earlier models by stressing the interdependent nature of the three components: group processes and outcomes, the methods (and methodologies) employed, and the EMS environment.

The paucity of consistent results that Kraemer and King (1990), Dennis et al., (1988) present only serves to emphasize

the undirected nature of existing GSS research design, and the lack of an accepted analysis framework at the present time. While the experiments referenced by Dennis et al., (1988) revolve primarily around decision rooms and LADNs, the absence of a framework to analyze common experiments has handicapped such evaluations until recently. The **method** aspect of Dennis et al.'s conceptual model coincides with the support provided by the integrated package of the software and the methodology inherent in the procedures, as well as the actions of a facilitator if one is used. The environment taxonomy presented in support of the conceptual model is a three-dimensional model with a group proximity, group size, and time dispersion axis. The resulting variation from DeSanctis and Gallupe's (1987) two-dimensional model lies in the distinction made by Dennis et al., (1988) of the dispersed environment aspect in which the environment is separated into multiple **individual** sites and multiple **group** sites. Dennis et al., (1988) provide some perceptive suggestions on the design considerations in support of these environments, based on their research and extensive experience with the PLEXSYS site.

This EMS model presents six sets of variables to describe the experiment with applications of: **group** (size, history, experience, etc.), **task** (type, complexity, etc.), **context** (organization culture, participation incentive, etc.), **EMS** (tool sophistication, methods, physical design, etc.), **process** (# of sessions, anonymity, degree of structure, etc.), and

outcomes (outcome quality and satisfaction, time required, # of alternatives, etc.). Similarly defined sets of meta-variables (i.e., group, task, context,...), with more specific sub-variables, to appreciate the significance of experiment results, will be incorporated in the next section of this chapter.

The value of Kraemer and King's paper on Computer Based Systems for Cooperative Work (1988) on GSS taxonomies lies not so much in the six environments they proposed (based on differing sociotechnical packages), but in the clarity their paper provides by weaving existing examples of tools, systems, and providers throughout their paper. Their expansion of the three complexity levels identified by DeSanctis and Gallupe (1987), the overview of the history of GDSS (GSS) development in the U.S., and the present and near-term future trends serve to put the study of GSS taxonomies in practical terms, making the next taxonomies discussed below all the more understandable. Kraemer and King (1988) do point out that:

> Few systems in these examples constitute a complete package (i.e., hardware, software, organizationware, and people....). To date, only one is available as a "turnkey" package (Perceptronics, Inc.'s GROUP DECISION AID). The other systems are in-house decision conference facilities that are available for outside use on a fee-for-service basis or systems that have so for only been used for research. The University of Arizona's PLEXSYS software is available for purchase and has been transferred to nearly a dozen universities and several corporate environments. (Konsynski et al., 1984-1985; Kraemer and King, 1988)

This is not just a function of the failure to supply adequate systems. The economic concept of supply and demand implies that there is possibly an insufficient demand for GSS. Few businesses can afford to invest in management tool research for research's sake. When GSS can be shown to provide predictable benefits for a given investment, then the demand can be expected to be more widespread. This low demand is quite likely a combination of the fact that most computer users have difficulty in grasping the cost effectiveness of GSS technology, and the inability of researchers to prove consistent results across laboratory experiments and field experiments. The next section of this chapter discusses taxonomies that directly address the problem of taking a proactive position on codifying GSS research to resolve inconsistencies.

D. CLASSIFICATION MODELS TO DIRECT RESEARCH

The Pinsonneault and Kraemer (1990) paper is included here because its taxonomy is such an integral part of the overall methodology of Gray et al., (1990). Also, a drawback in their application, as shown by Gray et al., (1990), clearly demonstrates the need for further codifying of the research model design.

The quotes at the beginning of this chapter (Kraemer and Pinsonneault 1989, Pinsonneault and Kraemer 1990) set the tone

for the proposed framework to support analysis of research to date in GDSS and GCSS. They state:

> We developed our framework for analysis from systematic review of research in organization behavior and in group psychology (Pinsonneault and Kraemer, 1989). Based upon that review, we conceptualize the relationship between meetings and group outcomes as involving three broad sets of factors...concerned with (1) the context, (2) the process, and (3) the outcomes of group interaction (task-related and group-related). (Pinsonneault and Kraemer 1990)

In their analysis, the focus on the identification of the effects of GSS context variables on group processes affected the task and group-related outcomes. Their taxonomy provided for 41 variables within the three broad sets of factors. These variables were applied to the published reports of 31 experiments. The model served to support analysis of the experiments of GDSS and GCSS research. While their table of results provides an exhaustive correlation of variables across experiments, the list of consistent findings is relatively short, but contains qualifying points addressing ambiguities found.

The key to obtaining significant GSS benefits to justify its commercial use seems to lie in reducing qualifying points to the bare minimum, and demonstrating a track record of repeatability. That is the apparent strength of the taxonomy proposed by Gray, Vogel and Beauclair (1990) in their <u>Assessing GDSS Empirical Research</u>. While this taxonomy is comprehensive in its approach to the problem of analyzing research, it is not used in its entirety in the literature

classification framework here due to the differing mission of the two papers.

The focus of Gray et al., (1990) is well defined by the following excerpt:

> The purpose of this paper is to propose a method for comparing experiments based on the classification scheme used by Pinsonneault and Kraemer (1990). The idea is to create a way of clustering similar experiments. Experiments "close" to one another should yield similar results, whereas experiments "distant" from one another may give quite different results. Furthermore, as new empirical results are presented, researchers will, by using the method, be able to compare their findings to those of experiments close to them. (Gray et al., 1990)

This idea may also be extended to provide the basis for a proactive approach to the issue of research contradictions. By using the knowledge of how the variables are weighted, the researcher could plan his experiment structure to deliberately force a clustering with other experiments (providing an advance hypothesis for testing). As Gray et al., (1990) point out, the framework could be used to find situations that differ from those previously reported. In any case, a wealth of information may be obtained in an analysis of research design to date by using their taxonomy, even if the clusters are not as prevalent as desired.

Table 3, reproduced from Gray et al., (1990), shows the metavariables (e.g., personal factors, situation), the operational variables (e.g., attitude toward group, ability to work in group), and the indicators (for the five variables they felt required further definition (e.g., previous group

TABLE 3

DETAILS OF THE GRAY-VOGEL-BEAUCLAIR RESEARCH MODEL
(reproduced from Gray, et al., 1990)

METAVARIABLES	VARIABLES	INDICATORS
PERSONAL FACTORS (group member attitudes, backgrounds)		
	1. Attitude toward group	
	2. Ability to work in group	
	3. Background of group members	
		a. previous group experience
		b. education
		c. average age
		d. computer ability
SITUATION (how group came together)		
	4. Reason for group membership	
	5. Existing social network of group	
	6. Stage of group development	
GROUP STRUCTURE (how group is organized)		
	7. Size of group	
	8. Density	
		a. number of people/terminal
		b. terminal separation
	9. Table shape	
TECHNOLOGICAL SUPPORT (characteristics of GDSS)		
	10. Degree of support (DeSanctis-Gallupe(1987))	
	11. Degree of anonymity	
	12. Chauffeur/facilitator	
	13. Interface	
		a. response time
		b. type of interface
		c. public screen
TASK CHARACTERISTICS (what the group does)		
	14. Complexity of task	
		a. complexity of problem
		b. complexity of response
	15. Nature of task	
		a. urgency
		b. importance
		c. routine or creative
		d. abstractness
GROUP PROCESS (how the group works as set up by experimenter)		
	16. Negotiation associated with task	
	17. Degree of consensus required	
	18. Communication supported	
	19. group structure imposed	
	20. # of meetings to accomplish task	

experience, education)) used in their model. The remainder of the method revolves around defining scales for the variables, determining the distance between pairs of experiments, and using the multi-dimensional scaling technique to graphically represent their degree of similarity. A valuable insight by Gray et al., (1990) points out that despite the attempt by Pinsonneault and Kraemer (1990) to segregate common experiments grouped by similarity of focus on GDSS or GCSS, the application of the taxonomy of Dennis et al.'s method does not demonstrate "clustering" (based on independent variables) that is desired to support robust conclusions. See Figure 6.

Dennis et al., (1990) asks for feedback from the research community on the choice of variables and scales for the method, as well as for feedback from the researchers whose results were assessed. This feedback should prove invaluable in validating this taxonomy and help to promote its widespread use.

IV. GSS RESEARCH ISSUES

A. INTRODUCTION

This chapter addresses research issues in GSS in three parts, and provides a classification scheme borrowed from the models, as proposed by Gray, et al., (1990) and Pinsonneault and Kraemer (1990). The scheme was used to support an analysis of 43 papers in the GSS literature to provide a representative overview of GSS research issues. The logic used to determine the paper selections in order (to provide a representative cross section of the field) is discussed, with an overview of the resulting data provided.

As Section B points out, the classification scheme for addressing the issues in GSS is adopted almost verbatim from the **research taxonomy** proposed by Gray, et al., (1990) and the **group/process/outcome** portion of Pinsonneault and Kraemer's (1990) GDSS taxonomy. In concert, these two taxonomies provide a comprehensive means of addressing the issues in GSS that arise when looking at the independent variables and their effects on the dependent variables of experiments in Group Support Systems. The resultant model serves to encompass the majority of the issues raised by the papers analyzed. Table 4 illustrates the classification method utilized in this chapter, and provides a tabular display of the general issues discussed by the articles.

The papers used to generate Table 4 were chosen based on three factors. First, an annotated copy of this thesis' database was generated by an iterative analysis of the references and bibliographies in the articles of the last two years of the Proceedings of the Hawaii International Conference on System Sciences (GSS articles), and in the special editions on GSS in the European Journal of Operations Research (Vol. 46), Decision Support Systems (Vol. 5, No. 2), and Management information Systems Quarterly (Vol. 12, No. 4). The lists of references provided by these articles served both as a supplement to the commercial database keyword search for GSS articles conducted in support of this thesis, and as a means of determining which articles would provide a representative cross section of the field, based on the frequency of citation by other authors in the field. This process produced the core of the articles referenced throughout this thesis.

In addition to the above papers, most of the research papers referenced in Pinsonneault and Kraemer's (1990) and Gray, et al.'s (1990) analysis of research experiments were also added for support. Several papers presented at the 24th Hawaii International Conference on System Sciences (1991) were specifically included in the generation of Table 4 to ensure that current focuses were reflected, and to approximate a reasonable cross-section of the field as possible.

In Section C., the predominant issues derived from these papers will be summarized to highlight some of the relevant trends brought out by Table 4.

The discussion of other issues in the last section is included to address the few issues that do not readily fall in the classification scheme of this chapter and Table 4. However, these issues bear noting as significant concerns in the field are brought forth.

B. FRAMEWORK FOR ANALYZING ISSUES IN GSS RESEARCH

This section explains the method employed in developing the framework for the analysis, the means by which the major issues were identified within the articles used, and a short discussion on how the issues were placed on the table, given that some of the nine main categories (meta-variables) may have up to two further levels of refinement possible (variables and indicators respectively).

The framework for grouping the issues addressed in the research papers was determined using the review illustrated in the Chapter III survey of taxonomies. This survey showed that the merging of two existing taxonomies was a logical choice. Just as Chapter V points out that a classification scheme for surveying the field of GSS literature will be slightly different from other GSS taxonomies in order that it might closely match this endeavor, this classification framework for analyzing research issues also differs from the scheme in

Chapter V for this discussion. No attempt is being made to foist another grand taxonomy on the field of GSS. The classification scheme here, as in Chapter V, serves only as a tool for the task at hand.

The framework adopted here takes its structure from two sources. The framework for the table of **independent variables** comes from the listing of meta-variables, variables and indicators used in Gray, et al.'s (1990) research model. It is understandable that this should provide a strong framework since it was generated for the specific purpose of classifying the research design (**independent variables**) of experiments in the GSS field. It is stated quite freely that it was not the intention of their (Gray, et al.'s 1990) model to examine variables not under the control of the experimenter. To represent these **dependent variables**, we turn to Pinsonneault and Kraemer's (1990) classification of empirical research, designed around studies of organizational behavior and group psychology. The portion of their model that describes the **group process** variables and the **outcome** (task and group-related) variables, covers quite well the potential **dependent** variables (and issues) of GSS experiments and literature.

The determination of what variables/issues the articles were addressing was made in two ways. The primary reference was the paper itself. The abstract, the introduction, and the conclusion were assumed to be the most relevant guides. Only when there was still doubt as to the primary focus of a paper

was the bulk of the paper used to modify the listing of issues. This was done to avoid cluttering Table 4 with secondary and tertiary issues, but also to avoid reinterpreting points the authors were highlighting in their main forums of discussion. A secondary source of information were the additional references by other authors in the papers. As a rule, the conclusions of other authors provided useful insights without significantly conflicting with the stated issues of the original author.

As there are three levels of refinement in each of the two sections of the model (the independent and dependent variables), it is worth noting how the issues were annotated. The general rule of thumb was that if an issue was stated in specific terms, it would be attributed to the most discreet level of refinement reflecting those specific terms. For instance, an article addressing the **depth of analysis** exercised by a group in a particular experiment could potentially have its appearance listed alongside the **Process** meta-variable as an issue, or alongside the **decision characteristics** variable under the **Process** meta-variable. But the best match of this topic would be the next level of refinement under **decision characteristics**, the indicator named **depth of analysis** (see page 41). Generally speaking, the line item that most accurately described the actual issue discussed is the appropriate location, with less specific issues being listed alongside the more general categories as necessary. By

definition, an experiment that addresses an **indicator** also implies that the corresponding variable and meta-variable have been addressed, and therefore should not be annotated to avoid cluttering the framework. The few issues or concerns that did not fit readily or closely to the categories of the scheme were retained for discussion later in this chapter.

C. PREDOMINANT ISSUES IN GSS RESEARCH

There were a number of trends that became apparent while generating the data for Table 4. These items will be discussed in the sequential fashion, as arranged in Table 4. It is recommended that Table 4 be referred to while reviewing the following comments for better understanding of the analysis.

1. Issues Concerning Independent Variables

The issues followed most closely by the researchers were related to independent variables and fell predominantly in the **group structure** and **technological support** categories. Other trends noticed in research issues are as follows.

The meta-variable **personal factors** did not receive a great deal of attention by researchers. Other than to note the difficulties and frustrations encountered in GSS by personnel with minimal computer experience, few references were made directly to this category.

Situation (or how the group came together) was most notable in the several references toward the indicator

TABLE 4

ANALYSIS OF PAPERS FOR GSS RESEARCH ISSUES

INDEPENDENT VARIABLE ISSUES META- VARIABLES INDICATORS		
PERSONAL FACTORS (GROUP member attitudes, backgrounds)		22, 28, 30, 40
1. Attitude toward group	●	
2. Ability to work in group	●	
3. Background of group members	●	27, 30, 36
a. previous group experience	O	
b. education	O	
c. average age	O	
d. computer ability	O	7, 8, 17, 26
SITUATION (how group came together)		2, 8, 22, 27, 36, 40
4. Reason for group membership	●	4
5. Existing social network of group	●	7, 22, 30
6. Stage of group development	●	24, 30, 36, 43
GROUP STRUCTURE (how group is organized)		22, 40
7. Size of group	●	7, 9, 10, 12, 29, 30, 36, 40
8. Density	●	4, 5, 7, 10, 15, 21, 30
a. number of people/terminal	O	10
b. terminal separation	O	
9. Table shape	●	10
TECHNOLOGICAL SUPPORT (characteristics of GDSS)		8, 13, 17, 19, 23, 30, 35, 40, 43
10. Degree of support	●	1, 5, 7, 12, 14, 21, 30, 32, 34, 37, 38, 40, 42, 43
11. Degree of anonymity	●	2, 6, 7, 10, 18, 20, 22, 29, 30, 42
12. Chauffeur/facilitator	●	11, 30
13. Interface	●	10, 23, 25, 26
a. response time	O	26,29
b. type of interface	O	29
c. public screen	O	29
TASK CHARACTERISTICS (what the group does)		2, 7, 18, 19, 22, 37
14. Complexity of task	●	3, 14, 30, 36
a. complexity of problem	O	
b. complexity of response	O	
15. Nature of task	●	12, 16, 27, 30, 36, 40, 43
a. urgency	O	
b. importance	O	
c. routine or creative	O	
d. abstractness	O	30

TABLE 4 (CONTINUED)

GROUP PROCESS (how the group works as set up by experimenter)		22, 43
16. Negotiation associated with task	•	31
17. Degree of consensus required	•	
18. Communication supported	•	10, 12, 24, 29, 30, 31, 36, 40
19. group structure imposed	•	14, 23, 24, 30, 31, 39
20. # of meetings to accomplish task	•	10

* Listing of Dependent Variable Issues and Number/Article cross-reference continued on next page.

TABLE 4

ANALYSIS OF PAPERS FOR GSS RESEARCH ISSUES

DEPENDENT VARIABLE ISSUES META-VARIABLES	INDICATORS		
PROCESS			
	1. Decision characteristics	●	
	a. time to reach	o	1, 3, 4, 12, 14, 15, 18, 23, 24, 27, 27, 29, 32, 34, 38, 40
	b. depth of analysis	o	13, 20, 23, 24, 31, 33, 34, 40
	c. participation	o	7, 8, 10, 12, 14, 16, 20, 21, 23, 24, 32, 33, 38, 40, 43
	d. consensus	o	7, 11, 14, 16, 18, 24, 29, 31, 37, 38, 40, 41, 42
	e. satisfaction	o	5, 6, 7, 12, 14, 15, 21, 23, 24, 26, 27, 29, 34, 39, 41, 42
	2. Communication characteristics	●	25, 29, 39
	a. task oriented	o	7, 24, 32, 38
	b. clarification efforts	o	6, 16, 20, 24
	c. # of comments	o	6,20,33
	3. Interpersonal	●	7, 24, 32, 38
	a. domination/power	o	7, 16, 18, 24, 27, 29, 37, 41
TASK (outcomes)			
	1. Decision characteristics	●	
	a. quality	o	1, 2, 4, 6, 7, 9, 12, 13, 14, 15, 16, 21, 23, 24, 31, 34, 38, 41, 43
	b. how many	o	4, 6, 9, 10, 14
	2. Attitude toward outcome	●	
	a. confidence	o	12, 14, 24, 30, 34, 39
	b. satisfaction	o	1, 4, 5, 6, 11, 12, 14, 15, 24, 26, 29, 34, 39, 43
GROUP			
	1. Satisfaction with group	●	6, 7, 14, 23, 24, 29

TABLE 4 (CONTINUED)

1	Beauclair, 1989	23	Kraemer and King, 1988
2	Beauclair and Straub, 1990	24	Kraemer and Pinsonneault, 1989
3	Bui and Sivasankaran, 1987	25	Mandviwalla, et al., 1991
4	Bui, et al., 1987	26	Nunamaker, et al., 1987
5	Cass, et al., 1991	27	Nunamaker, et al., 1989
6	Connolly, et al., 1990	28	Nunamaker, et al., 1989
7	DeSanctis and Gallupe, 1987	29	Nunamaker, et al., 1988
8	DeSanctis and Gallupe, 1985	30	Pinsonneault and Kraemer, 1990
9	Dennis, et al., 1991	31	Sengupta and Teeni, 1991
10	Dennis, et al., 1988	32	Siegel, et al., 1986
11	Dickson, et al., 1989	33	Smith and Vanecek, 1989
12	Easton, A., et al., 1989	34	Steeb and Johnson, 1981
13	Ellis, et al., 1989	35	Stefik, et al., 1987
14	Gallupe, et al., 1988	36	Suchan, et al., 1987
15	Gallupe and Keen, 1990	37	Tan, et al., 1991
16	Hiltz, et al., 1986	38	Turoff and Hiltz, 1982
17	Hiltz and Turoff, 1981	39	Venkatesh and Wynne, 1991
18	Hiltz, et al., 1989	40	Vogel and Nunamaker, 1990
19	Huber, 1984	41	Watson, et al., 1988
20	Jessup, et al., 1990	42	Winneford, 1991
21	Jarvenpaa, et al., 1988	43	Zigurs, et al., 1988
22	Jessup, 1987		

(sub-variable)[6] of **stage of group development**. A great deal of discussion relating to the relative importance of group development in the use of GSS and its role in the realization of GSS potential exists in these articles.

Group structure is a frequently altered variable used to analyze the differing effects within a particular research experiment. The study of group size[7] is already known to produce differing results in traditional group behavior analysis. What is not yet known is how this variation affects GSS usage, or at which level the transition occurs. The density indicator of this category really reflects whether research was conducted in a single location, or whether a distributed GSS or teleconferencing scenario was employed.

Technological support was the most frequently mentioned (and modified) of the independent variables. Papers listed directly to the right of this meta-variable reflected broad comments concerning the type of technological support provided in GSS research and its proposed significance. The **degree of support** variable[10] almost exclusively indicates research that specifically analyzed the use of GSS between groups employing differing levels of support (frequently a manual support control group versus a GSS-supported one). The **degree of anonymity**[11] also received a fair amount of analysis. This is not too surprising, given its known role in traditional group behavior and the need to understand its

relevance in GSS use where it could be easily modified. Surprisingly few papers existed that analyzed the role or effect of facilitator in GSS scenarios, especially given the frequency of comments recognizing its significant effect on the GSS group process.

Another area that received surprisingly little analysis was the meta-variable of **task characteristics.** Given the significant role that this review of the literature imparts to task nature and complexity, a greater importance would have been expected in controlling this variable.

Analysis of **group process** as an independent variable generally revolved around the sophistication and range of the **communication support**(18) provided, or the category **group structure imposed**(19) explaining the degree of protocol imposed. The variables of **group structure imposed** (#19), and that of **degree of support**, (#10 under technological support), were not always clearly distinguishable from each other in the various authors' work. This is understandable as both have common ground in the concept of organizationware, as used in this paper and in Kraemer and King (1988).

2. Issues Concerning Dependent Variables

Authors in the GSS literature were most descriptive in the analysis of issues surrounding the dependent variables, or generally speaking, the effects seen by GSS application. An overview focus of the papers was on the analysis of the group

decision process variables, and the **task outcome** quality and satisfaction issues.

The authors reviewed in Table 4 analyzed in greatest detail the group process variable of **decision characteristics**(1) the closest, making their study relatively evenly spread between sub-variables of: **time to reach a decision; depth of analysis** employed by the participants; the **extent of participation** by all members; the **consensus** reached over the final decision; and the **satisfaction** felt by members over the final decision. It became obvious that the impact of GSS on the task (decision) process **characteristics** is a key issue to the field with a multitude of variables to be considered.

The **communication characteristics**(2) variable under group process received less attention, with most of the comments reflecting how interpersonal communications appear to have been altered by the imposition of GSS technology and system support.

It is in the **interpersonal domination/power (influence)** variable that some interesting observations were made. Several discussions cited the alteration in influence and politics in GSS environments that is often an important part of traditional group dynamics. One disturbing aspect of this effect is that it results not just from the anonymity provided by the GSS environment, but may also be induced by nature of the fact that most GSS tools and systems work on the

rational model of decision making. While this decision making theory is most easily modeled by GSS technology, it is by no means the driving argument behind the majority of human decision making, particularly in non-cooperative or mixed motive scenarios. While the anomaly of influence and the rational model may be unavoidable, given the present state of group behavior study and GSS technology, it is certainly one factor that researchers and practitioners cannot take lightly.

Quality of task outcome and the group's satisfaction with the outcome were the predominant variables analyzed by researchers under the meta-variable of **task (outcome)**. The comments by authors on the aspects of **task outcomes** in GSS environments followed quite closely the categories of **decision characteristics**(1) (quality and # of alternatives generated), and that of **attitude toward outcome**(2) (confidence in final decision and satisfaction that it was the right one).

The last dependant variable issue, **group**, introduces the topic of member **satisfaction with the group**(1) itself. Given the preponderance of laboratory experiments in GSS research and its accompanying artificialities of group membership, it is understandable that in general this will not be an overriding concern until more realistic commercial scenarios can be obtained from field studies.

It is possible that the density of comments in the area of dependent variables versus those in the independent

variables is in part due to the lack of coordination and a supporting structure for GSS research experiment (independent variable) design. Researchers have been thorough in their attempts to analyze the results of their studies, but the lack of a widely-accepted taxonomy for research design manifests itself again in this review.

D. OTHER ISSUES

There were several of comments, or issues, noted during this analysis of GSS literature that bear repeating. These issues did not readily fall into the classification framework, but are no less significant for that fact and as such are listed below.

The imbalance of field studies versus laboratory experiments was noted as a deficiency by a number of authors, Kraemer and King (1988), Kraemer and Pinsonneault (1989), and Gray, et al., (1990), amongst others. Kraemer and King (1988) were also among the authors that brought up the fact that the rational model is not the only one that should be used in implementations of GSS. Kraemer and King (1988) also called for a rigorous check of past data to produce valuable information in support of future research. Jessup, et al., (1990) comment on the lack of spontaneity that may be suffered by inexperienced GSS users, and Beauclair and Straub (1987) are among the authors that point out the gap present between commercial hardware and software availability versus that

being modeled in the research field. As a closing comment to this chapter, Suchan, et al., (1987), amongst others point out the ever-present need to consider organizational culture and values when designing GSS for commercial implementation.

V. PROPOSED CLASSIFICATION FRAMEWORK

The format of the classification schema developed in this thesis will incorporate a number of the methodologies previously listed. Different methodologies are somewhat biased toward supporting specific foci in the field of GSS. This classification scheme is also biased to support its primary purpose. Its primary purpose is to provide a framework and a schema specific enough to describe the articles in sufficient depth for directed study of any form of GSS literature.

The classification scheme is designed to provide (as a minimum) a skeleton of the article's content by abstract analysis. A classification would obviously be more descriptive if the data for each article were gleaned from a review of the entire paper. This task, however, is beyond the scope of this thesis. An analysis of the papers referenced in this thesis and of a cross-section of the papers from the 24th Hawaii International Conference on Systems Sciences show that abstracts are of sufficient detail to be a useful tool for use in the literature classification scheme. The classification scheme is expected to be a ready reference for obtaining database information about specific topics of interest or for obtaining general information about published research in the GSS field to date.

The additional research necessary to apply the framework for the remainder of the database articles here and those of less commonly referenced articles remains to be conducted. The thrust of this thesis has been to develop an extensive database in order to support a tutorial and survey of the GSS field to date, and to conduct analysis to validate the proposed literature classification scheme and the analysis of research issues presented in Chapter IV.

The literature classification scheme presented annotates the articles addressing subjects in the overall categories of **Environment, system Task/Purpose, Support components.** The intended scope of each of these categories is explained below as well as the amplifying information provided by the annotating symbols (↕, ↑, ↓, X). The **naming convention** category will discuss the general thrust of the reference listed (whether it is a description of Research conducted, Instructional purposes, etc.). Finally, a brief review provides the process used in generating the articles that forms the heart of the database.

These categories are a compilation (and condensation) of the current taxonomies discussed in Chapter III, tailored to reflect the information readily available in abstracts, and designed for simple transfer to a database and subsequent display in a legible tabular format.

A. GSS ENVIRONMENT DIMENSIONS AS CLASSIFIERS

1. GSS Task/Purpose

Task relates quite closely to the various subdiscipline titles of Group Decision Support Systems (GDSS), Negotiation Support Systems (NSS), and Computer-based Systems for Cooperative Work (CSCW). At the risk of oversimplification, generally GDSS support **choice-related tasks**, CWCW or GCSS support **generative**-related tasks, and that NSS may be said to support **negotiative**-related task purposes. This simplification is made to strictly aid in conceptualizing the broad themes and designs running through the GSS field, and realizing that in actuality a great deal of overlap may occur. As stated by Nunamaker, et al., (1989):

> The subtasks of any overall task can vary substantially over time and be even further decomposed into subphases of activity as a group addresses a complex problem or question. Groups tend to work back and forth between various task types as they deal with different aspects of their primary focus. Thus a circumplex of tasks should not be viewed as merely a static representation within which problems can be neatly categorized but as a more dynamic means of assisting in the tracking of group activities within a general task arena. (Nunamaker, et al., 1989)

An understanding of the tasks and subdiscipline focus is also instrumental to understanding the key research issues of GSS and the difficulties being encountered in obtaining clear-cut conclusions from research.

The general focus of each of these three subdiscipline areas,(GDSS, NSS, and CSCW), dictates the use of different tools and the recognition of special problems that each

encounters. It is useful when trying to interpret the results reported by an experiment to try to determine the task purpose for which the design is being employed. The determination of the main focus task or whether the GSS approximates a GDSS, a CSCW, or a NSS, helps provide one of the independent variables for the research design setting as an aid toward interpretation of results.

Of these three focuses, GDSS receives the majority of the attention and most frequently come to mind when thinking of Group Support Systems. Where a GDSS generally supports cooperative decision making and the structuring of the group decision process, a NSS (or GNSS) deals with the unique aspect of operating in a non-cooperative environment, in which hidden agendas and incomplete information sharing complicate the issue. The CSCW (or Group Communication Support System [GCSS]) is designed to assist in generating and collecting ideas and supporting the communication process to do so. Some facilities are designed to support several of these tasks, (Pinsonneault and Kraemer, 1990), and in fact, the distinction between GDSS/CSCW/NSS is not even made during some studies. As pointed out by Dennis, et al., (1988), the distinction is blurred, and in time the supporting technologies may merge to form a single system capable of supporting all tasks.

DeSanctis and Gallupe (1987) propose six task types grouped under three task purposes that correspond closely to the three GSS sub-disciplines presented here: intellective

and preference type tasks that would fall under the Choice task purpose (GDSS), cognitive conflict and mixed motive task types under the Negotiate purpose (NSS), and planning and creativity tasks under Generate (CSCW). These task types are used to elaborate the primary thrust of each of these sub-disciplines and the supporting associated processes and procedures (organizationware).

a. Choice Tasks

The role of intellective choosing task type is to develop rationale and logic for existing alternatives in order to determine the most correct choice. In preference choosing, the decision results more from weighing, ranking, and choosing the most favored alternative. (DeSanctis and Gallupe, 1987)

Examples of choice support features would be automated Delphi Technique, Nominal Group Technique, and aggregation of preferences. Intellective choosing more specifically employs tools supporting data access and display, synthesis and display of choice rational, forecasting models, multi-attribute utility models, and promotes "rule based discussion emphasizing a thorough explanation of logic." (DeSanctis and Gallupe, 1987) Preference choice is distinctly different. Its slant toward the most favored solution would be assisted by preference weighing, alternative ranking and voting schemes, social judgment, automated Delphi Technique, and rule-based discussion emphasizing equal time to present

opinions. (DeSanctis and Gallupe, 1987) A review of the GSS literature suggests that a GSS may generally be associated with that of choice task support as its primary focus.

b. Negotiate Tasks

The **negotiation** task purpose evolves from two unique aspects of non-cooperative group dynamics; the first is that the (group) problem representation is inherently in error because of incomplete information sharing by members, and second, that the final solution is not necessarily the "best" (most logical) solution, nor the most favored solution, but rather a compromise solution that likely evolved as a result of the negotiation process. (Bui, et al., 1987) DeSanctis and Gallupe (1987) break the **negotiate** task purpose into **cognitive conflict** and **mixed motive** type tasks. These two tasks require the use of procedures and features capable of handling voting solicitation and summarizing, stakeholder analysis and resource allocation models, decisions over who has the floor via a rule-based facilitator, conflict resolution models and Multi Criteria Decision Making (MCDM) models. (DeSanctis and Gallupe, 1987) Software and organizationware such as that listed above is specifically needed to overcome situations that plague non-cooperative situations such as:

> ...varying levels of mistrust, misrepresentations to outperform or even hurt others, and sometimes with the unwillingness to resolve the collective problem. (Bui, 1987)

Recognition of the unique problems associated with non-cooperative or mixed motive meetings allows for obvious differences involved in the design of Negotiation Support Systems (NSS), a unique form of GSS.

c. Generate Tasks

The third category, representing systems supporting **generate** task purposes, reflects GSS that are structured primarily to support the communication needs of groups. The concept of the **generate** task appears synonymous with Pinsonneault and Kraemer's description (1990) of Group Communication Support System (GCSS) whose main purpose is to reduce communication barriers in groups. The tasks that DeSanctis and Gallupe (1987) discuss relate closely to those of the **planning** and **creating** task types. These two task types fall under the task purpose of **generating** ideas and actions. Applications of this broad task purpose and its associated task types are seen in the use of GSS for brainstorming, mission development or strategic planning, and group document generation. These systems require features that support idea generation and organization, information storage and retrieval, automated risk assessment and planning tools and communication/contribution protocol tools. (Pinsonneault and Kraemer 1990; DeSanctis and Gallupe, 1987)

Several points need to be made concerning the task/purpose classifiers. Some authors describe models that classify GSS by titles (GDSS, NSS, CSCW/GCSS), others by the

primary focus of their support features (voting/analytical modeling, communication/idea organization, game theory/ conflict analysis), and still others by grouping them under broad task, or purpose types. The classification by GSS task or purpose type is the method to incorporate when surveying literature as many articles make no distinction by title between systems that handle, for instance, cooperative vs. non-cooperative decision making, or idea generation vs. decision making, and lump them all under the title of GDSS. Classification using the GSS focus title (GDSS, CSCW, NSS) will be done only when it is not obvious what the general purpose of the GSS is. The list below serves as a reference to the distinctions general task purpose categories, the GSS subdiscipline that generally focuses on that task, and is followed by a brief review of the tool types normally associated with that task.

- Choice task purpose: GDSS, intellective/preference task types, cooperative decision making tools.
- Generate task purpose: CSCW/GCSS, planning/creative task types, idea generation/organization tools
- Negotiate task purpose: NSS/GDNSS, cognitive conflict/ mixed motive decision tools.

2. <u>GSS Environment Physical Design</u>

With the four physical examples of GSS from this paper's tutorial in mind, (Decision Room, LADN, Legislative Session and Teleconferencing), a 3-D model is presented that assists in categorizing the various GSS likely to be

encountered in a review of research article abstracts. This use of a 3-D model in describing a GSS environment physical design is not new, but rather is a simplification of the models proposed by DeSanctis and Gallupe (1987) and Dennis, et al., (1988).

a. Group Size

Although the principles of group dynamics theoretically apply to groups from very small to very large, several significant characteristics differ with size. As the number of members goes up, the number of exchanges rise dramatically (with their duration and intimacy declining), consensus reaching becomes harder, with social ties and group satisfaction tending to decline. As could be expected, the most appropriate tools to be used will also vary with group size. Where anonymous message exchange may be more valuable in small groups, vote tallying and display software may be more important for large groups. (DeSanctis and Gallupe, 1987). An additional factor when considering group size is the fact that a "large" tight-knit group of common background may appear to be a smaller group than a group with fewer members of varying cultures (Nunamaker and Vogel, 1989). For purposes of this paper, the convention proposed by Dennis, et al., (1988) to consider groups of ten persons or less as small, and greater than ten as a large group will be adopted here as a workable definition.

b. Group Proximity

Group proximity provides another variable widely used in differentiation of GSS environments. Proximity reflects the determination of whether the GSS provides a face-to-face situation or whether it supports differing geographic locations. The aspect of multiple sites has also been further expanded to break the dispersed site concept into two facets: multiple **individual** sites and multiple **group** sites. (Dennis, et al., 1988; Nunamaker and Vogel, 1989) For simplicity sake, this distinction is not elaborated on here as the basic concept is the same and the tools required for these variations are described in the discussions of LADNs and teleconferencing. The requirement for remote meetings may result from necessity if the parties are geographically separated, or may be simply for convenience sake. As the removal of face-to-face communications engenders some distinctly different group dynamics, however, it is not a choice that should be made lightly if it is made only to support convenience of the participants. The removal of the face-to-face verbal exchange generally necessitates replacement by audio, video and data channel links (e.g., teleconferencing), in addition to the computer-based support.

c. Time Dispersion

The third dimension of the environment taxonomy is one presented in Dennis, et al., (1988) and Nunamaker and Vogel (1989) with the discussion of the time dispersion of

possible GSS environments. GSS meetings do not necessarily have to happen in an uninterrupted fashion. Although E-mail and teleconferencing are rudimentary forms of asynchronous meetings, they lack the dynamics of group interactions of the GSS concept. The GSS time dimension can encompass the time dispersion from that of synchronous meetings of different size and proximity environments to the asynchronous contact of individual or sub-groups working at different times on a common theme. Excluding the time dispersion dimension, the four environments discussed previously are formed by the intersection of the proximity and group size axis as shown below.

```
                        -------------PROXIMITY---------------->
              small |  Decision Room          LADN
 GROUP SIZE         |
              large |  Legislative Session    Teleconference
                    \/
```

In developing the literature classification scheme, the GSS environment physical design portion (including proximity, size, and time) of the taxonomy has been expanded slightly to include the variable labeled here and described below as the GSS sophistication level. The variables listed in the Environment category are designated with arrows to indicate the end of the dimension axis that the variable relates to. For instance, if an article addresses a **large** size group, an up arrow (↑) is displayed, if it were a **small** group size, a down arrow (↓). If the article references a

scenario in which the results of effect of **varying** group size was being analyzed, an up and down arrow (↕) is entered. (This generally will be seen in Research articles when the effect of varying support components or environments is examined). This convention will exist any time that the arrows are used in the taxonomy, (i.e., also in Support Components where varying the range of tool or organizationware support may be addressed).

- ↑ (up arrow) indicates **greatest** level/extent
- ↓ (down arrow) indicates **least** level/extent
- ↕ (up and down arrow) indicates **varying** levels/extent

Sophistication in the Environment category refers to the level of technological support discussed in the article. Generally, the low end of this scale occurs when a manual or unsupported group process is being conducted to provide a control group for comparison of processes/outcomes with a group using a support system. The high end of the scale would be an integrated multi-discipline GSS, such as PLEXSYS.

As discussed above, <u>proximity</u> reflects groups that are meeting in the same room, or face-to-face, at the "least extent" end of the scale, and ranges to distributed GSS environments at the "greatest extent" of the Proximity scale,

such as Xerox PARC's Commune (teleconference), or Carnegie-Mellon's Converse (LADN) systems.

The **time** factor is a function of whether the article addresses synchronous meetings at the "least level" end of the Time dispersion scale, or some variation of asynchronous meetings at the "greatest level" end of the scale. Examples of asynchronous meetings are seen in sophisticated E-mail or collaborative document generation support systems.

The variation in **group size** is a fuzzy variable as most abstracts and introductions simply characterize their groups as small or large, and leave their interpretation of those terms or the actual size by number to be discussed in the bulk of their paper. Once again, given the limited review expected of most papers placed in this scheme, unless an actual number is stated, the authors' interpretation of group size will stand. When size by number is given, this taxonomy utilizes the cutoff recommendation of Dennis, et al., (1988) as ten or less being small (the "least" extent of the Size scale), and greater than ten being large (the "greatest" end of the scale).

3. <u>Support Components</u>

The **Support Component** category indicates whether the paper in question specifically references the category of software or organizationware tools. Software refers to discussions dealing with particular modeling tools or specific

attribute automation within a larger system. Examples of this are the idea generation (Electronic Brainstorming (EBS)) tool within the PLEXSYS system, or the electronic chalkboard (Sketchtool) aspect of the COLAB system. (Nunamaker and Vogel, (1989))

Organizationware reflects any emphasis placed on the presence or effect of system procedures and protocols (embedded in the software or followed by consent) that might be of interest. Examples of these procedures might be the protocol for voting, idea exchange, or problem formulation.

As some research has addressed the differences in group processes or outcomes based on varying the **extent** of support component control, up and down arrows (↕) have been assigned vice just an X in their corresponding cell.

B. NAMING CONVENTION

This column in the classification scheme gives the reader a quick sense of the main theme of an article. The first letter of the themes recognized here, (<u>R</u>esearch, <u>I</u>nstructional, <u>C</u>lassification, and <u>D</u>esign), is used as a mnemonic device to indicate which of the four themes is being addressed as titles of articles are often not sufficiently descriptive.

The primary need for this category arises from the need to separate articles providing quantitative research data in the field of GSS and those that simply provide further analysis of other reports or previously reported data. One of the self-

stated faults in the field of GSS is the paucity of actual field studies versus laboratory experiments. Therefore, articles addressing Research data are further amplified by the addition of the letter L if the research is a laboratory experiment, F if it is a field study (generally a commercial or bureaucratic scenario), or a S if it reflects a case study. Lack of an amplifying annotation should be interpreted as a reflection of no comment or of insufficient data for a determination to be made, vice an oversight or violation of the schema.

Rather than limiting the annotation of articles not directly related to research as simply instructional (I), two additional clarifications became useful during the literature review. Instructional articles that specifically forward proposed classification schemes are annotated with a **C** in this column. The last variance used, the letter **D**, stems from the desire to distinguish papers that seek primarily to describe the design or architecture of new or proposed GSS tools or systems. The inherent value in being able to rapidly distinguish articles dealing with new ventures in the field make this classification aid necessary.

An example of the proposed literature classification scheme is provided below (Table 5) with a couple of representative sample articles.

TABLE 5

LITERATURE CLASSIFICATION FRAMEWORK

	THRUST	ENVIRONMENT				TASK/ SUPPORT			SUPPORT/ COMPONENT	
BIBLIO GRAPHY#	OF PAPER	SOPH	PROX	TIME	SIZE	CHOI	GENR	NEGO	S/W	ORGW
38	I		↑	↓	↓		X			
53	I	↕					X			
234	R L	↕	↓	↓	↓	X				
266	R L	↕		↓	↓	X				↕

Sample corresponding Appendix A entries follow.

38 Chang, E., Kasperski, R., Copping, T., 1991, "Group Coordination in Participant Systems," 24th Hawaii International Conference on System Sciences, Vol. 3.

53 Dennis, A., Valacich, J., Nunamaker, J., 1991, "Group Sub-group and Nominal Group Idea Generation in an Electronic Meeting Environment," 24th Hawaii International Conference on System Sciences, Vol. 3.

234 Tan, B., Wei, K., Raman, K., 1991, "Effects of Support and Task Type on Group Decision Outcome," 24th Hawaii International Conference on System Sciences, Vol. 3.

266 Watson, R., DeSanctis, G., Scott, Poole M, 1988, "Using a GDSS to Facilitate Group Consensus Some Intended and Unintended Consequences," Management Information Systems Quarterly, Vol. 12, No. 3.

C. A DATABASE FOR GSS LITERATURE

The database of GSS literature generated in support of this thesis' analysis and for follow-up application of the classification framework was generated as described below.

The bulk of the articles in the database were generated by a keyword search of several computerized commercial research

and library reference material databases by the Dudley Knox Library, Naval Postgraduate School in Monterey, CA. Keyword searches being mechanistic in their approach, a number of articles were subsequently screened as being unintentional keyword matches or of insufficient relevance to be included.

One of the most valuable methods used in the research was to review the bibliographies of articles in recent year editions of the Hawaii International Conference on System Sciences (HICSS) and of those articles in special GDSS (GSS) editions of journals and publications. The research of these bibliographies produced not only a wealth of additional GSS articles, but also provided a means of determining the most widely-referenced articles in the GSS literature. For the purpose of the Tutorial and literature analysis of this thesis, the identification of authoritative articles in the field proved invaluable. Those frequently-cited references form the core of the articles listed in the reference section of this thesis.

Efforts to further extend the breadth of the bibliographic database would be best served by reviewing the complete set of GSS articles in the last three years of the HICSS proceedings and any special journal editions on GSS that are published after June of 1991.

VI. CONCLUSION

A. DISCUSSION

Despite the fact that the field of GSS is slightly more than a decade old, it is still is undergoing the growing pains of a fledgling field of research. This difficulty is due in no small part to the rapid developments in the computer industry and to the fact that GSS operates in a not yet fully understood field of group organization and behavior. Personnel in the GSS field seem to be constantly redefining the scope of their research and the results of their experiments.

Considerable hope for progress in research still exists, as well as to develop large-scale commercial implementation. The generalized benefits covered in Chapter II hold true despite the conflicts in other research results. A review of GSS literature points toward an ever-increasing interest in developing a common conceptual scheme for organizing and coordinating the efforts of researchers. A widely-accepted taxonomy in the field of GSS should not be viewed as an obstacle to innovation, but rather as a means to reduce duplication of research efforts, and to support the verification and validation of experimental results. Establishing a few robust truths about GSS issues will go a long way in validating the usefulness of GSS technology, of

promoting field studies, and as such, will promote the commercial industry enthusiasm that will foster continued improvements.

This paper approaches the lack of strong direction in GSS research by providing a tool to aid in the categorization of existing GSS literature and to provide an informed analysis of research to date. The literature classification scheme proposed here is designed to initiate the development of an extensive database of GSS literature, while concurrently developing a classification structure that aids in the conversion of the GSS literature database into an information tool better suited to support GSS research. The proposed framework serves to provide a database record of GSS literature using information derived from abstracts in the GSS field literature.

An extension of this literature classification idea was employed in Chapter IV to support an analysis of GSS research issues, as determined by a cross-section of GSS literature. This analysis and a discussion of the emerging trends uncovered in Chapter IV are displayed in a tabular fashion in Table 4. The issues from the 43 papers selected as representative articles of the field were evaluated by their relative position to the independent or dependent variables in research design. All but a few of the research issues raised fell into a group of over 40 possible topics provided by the framework used in Chapter IV, and validating the use of the

framework as a comprehensive tool. The framework supporting this analysis was done using existing taxonomies in the field. It is hoped that the authors of the papers reviewed would assist in correcting any misinterpretations noted in references to their research if they have occurred, along with any recommendations on improving the framework.

B. FINDINGS AND DIRECTION FOR FURTHER WORK

While the review of GSS literature, and the generation of a classification scheme to aid in its utilization, served as the main thrust of this paper, the analysis of research issues generated justified the addition of several further items for future study and research.

The primary focus for future research should now be directed toward applying the literature classification structure of Chapter V to the database reflected in the Appendix of this paper. Since this database is not yet an exhaustive one, additional efforts are called for to verify its comprehensiveness, and to ensure it is brought up to date periodically. One benefit already realized from the classification of the literature and its transferral into a database has been the relative ease of identifying and analyzing the papers concerning GSS research issues provided in Chapter IV.

The ability for researchers to communicate with in their field of interest and to keep their knowledge of the

state-of- the-art up to date is particularly critical in fields encountering rapid growth. The literature classification scheme proposed here simply provides a tool to parallel the efforts of researchers making similar efforts in promoting coordinated research design and analysis. An understanding of the path followed can be invaluable in deciding the choice of paths ahead.

APPENDIX

LITERATURE SURVEY DATABASE

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